Interim Progress Report 2006
Human Dimensions of Global Change Research (HDGCR) Program

Project Title

Decision Support System for Agricultural Applications of Climate Forecast in West Africa

Investigators
<u>University of Florida</u>

Shrikant Jagtap (Principle Investigators), Ag & Bio Eng., Uni. of Florida
Jim Jones, Ag & Bio Eng., Uni. Of Florida
Ken Boote, Agronomy Department, Uni. Of Florida

<u>Ghanian Research Team</u>
Samuel G.K. Adiku (Soil-Crop-Climate Modeler) Dept. Soil Science, Uni. of Ghana, Legon
J. B. Naab (Agronomist and Soil Scientist), SARI, Wa Office, Wa
D. S. Dzorgbo **(**Social Scientist) Dept. of Sociology, University of Ghana, Legon
Andy Nkansah (Agro-meteorologist) Meteorological Services Department, Accra

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I. Preliminary Materials

A. Project Abstract

Farmers in Ghana require both the long-lead climate forecasts, downscaled to their region, as well as advice and inputs from local support services (i.e. meteorological services, ministry of agriculture, financial institutions and extension agencies). It appears that the support services sector is unaware of the emerging capacity in climate science in forecasting rainfall. Peanut is not only a major high-protein and major vegetable oil food in the Ghanaian diet, but it is also a cash crop and the cake remaining after oil extraction offers high quality feed for animals. Because local and international markets exist for peanuts, they provide an essential opportunity for small-scale subsistence farmers, many of whom are women, to generate income and improve living standards for themselves and their families. This research project is developing climate-forecast-based decision support systems that will enable support services to routinely evaluate risks and opportunities for crop production in Ghana using climate forecasts. We are exploring with a family of crop models, how various responses to ENSO events might affect crop production. In the second purpose, our goal is to assess the potential added value of providing more information to support services and farmers than is currently available through climate forecasting. This will be achieved by coupling climate forecast information with further model analyses to provide a better context for decision makers and producers, and then ask if this more elaborate information gives them any more flexibility and decision options than the climate data alone. In the third phase, we will design and test the decision aids that would be needed by support services so they can provide logistical support to farmers. Improved climate and weather information will lead to more informed management decisions and reduced risks for yield losses.

B. Objective of Research Project

This research project will assess the factors- both scientific and societal – affecting the use of long-lead climate forecast by government, banks, and extension services (referred to as support services hereafter) and to develop information for use by farmers for making informed decisions. We have four specific objectives to be achieved over a three-year duration: (1) Document knowledge of climate variability and its impact on peanut production among the major stakeholders in the agricultural sector in Ghana and determine how these stakeholders use (do not use) the knowledge to plan their operations, (2) Develop a climate diagnosis system for downscaling climate forecasts at different locations and for various times of the year and disseminate them along with a package of recommendations for managing crop production though existing mechanisms and institutions., (3) Develop decision aids to forecast the impact of climate variability on peanut production and to inform all stakeholders of those risks and management options that reduce them, and (4) Evaluate the use of decision aids within in each institution and how it impacts policy decisions they make and ultimately how it benefits peanut farmers.

C. Approach by objective

1. Using a participatory interactive process we will synthesize how the effects of climate variability are perceived and how climate forecasts and products are used (or not used) by stakeholders in support services sector as well as farmers. Through this objective we intend to address an important goal of the HDGCR program by focusing on several essential but weak institutions that empower societies' use of climate forecasts in developing countries.

2. Highly erratic rainfall and low water holding capacity soils are major features of Ghanaian production systems. Therefore any advice needs to be site specific. To achieve this we will collect a comprehensive historical daily weather data in pilot study regions. Weather data at each location will be categorized by October-December ENSO phase. Then statistical methods will be used to determine the underlying probability distributions of monthly rainfall and temperatures associated with each ENSO phase at each location. In doing so, we will endeavor to present climate information as a starting point in discussing climate variability and climate forecasts, which can be used by stakeholders to assess risks. We will model the daily weather data using a locally adapted weather generator conditioned on ENSO phases for input into a peanut crop model. Repeatedly using the generated daily weather series, consistent with a given climate forecast, and a peanut crop model, we will obtain frequency distributions of yields under forecast climate scenarios. This forecast-specific frequency distribution combined with each alternate peanut management decision will create a probability distribution to facilitate risk assessment and further decision-making.

3. Studies in the USA, Australia, and some parts of Africa have reported that seasonal climate forecasting offers potential for improving management of crop production risks. The situation in W. Africa is unique; it appears that farmers there are most likely to benefit if seasonal climate (i.e. rainfall) forecasts are distributed as an integral part of an extension package that includes discussion of the nature of the forecast, potential response strategies, and risk management options. A range of tools and concepts have been developed to deal with the need to reduce economic loss in dry years, while taking advantage of good seasons by adjusting inputs, management, or crops. These include response farming in which the crop is managed in accordance with the rainfall prediction based on the date of onset of the rains and actual amount received in the early part of the season. Other tools include crop simulation models linked with models of daily rainfall accounting for El Niño effects. We will pursue several participative systems approaches involving simulation-aided discussions with support services and decision makers for understanding and analyzing decision processes as they relate to use of climate forecasts to assist farmers in Ghana.

4. *Evaluating the use of decision aids within in each institution* will enable us to identify and resolve problems to operationally use the prototypes decision aids to be developed. We will work with all stakeholders to evaluate the utility of the systems and to obtain feedback to improve it. We will also identify what adjustments in the climate forecast tools/products can be made to maximize the probability that stakeholders will take action and correctly use the products. Support services personnel from each of the three Agroecological zones (Humid, Savanna, and Semi-arid) will be invited to participate in training program given jointly by both the UF and Ghanaian teams.

D. Description of any matching funds used for this project.

The project is paying 50% of the salary support for PI. All other co-operators are being paid by their host institutions. We estimate that additional matching support from UF amounts to $20,000/year and that from the four Ghanaian collaborators about $ 50,000/year.

II. Interactions

A. We surveyed twenty-six (26) groundnut farmers in six villages of Akatsi district in southern Ghana and documented (1) land-ownership, (2) land-allocated to groundnuts, (3) sole or mixed-farming, (4) volume of harvest sold in the market at the harvest, (5) and their general perceptions on climate variability, access to forecast climate information and their coping strategies.
B. We also surveyed 21 farmers in two villages near Wa to document how they (1) select which groundnut variety to plant, (2) When to plant it, and (3) how much they produce.
C. 2006-Climate forecast being La Nina, based on JMA SST anomalies between Oct-Feb was shared and explained to the staff of the Ministry of Agriculture, non-governmental agencies and Seed

Growers Association. These stakeholders were encouraged to take into considerations this forecast in their management recommendations for the cropping seasons.

III. Accomplishments

1.0 _Survey of Groundnut Production Practices in the Akatsi District of Coastal Ghana_ **–**The Akatsi district is situated within the southern coastal zone of Ghana and occupies about 90.6 km^2. It has nearly one million people, mainly farmers and with good road connections to cities in the region. This woodland savanna region receives an annual rainfall of 930 mm, 60% of which falls during the major season from March to July and the rest falling as minor season rainfall from September to November. August is a dry month. Soils of the region are light textured and belong to the Acrisols group in FAO-methodology. Textural analysis of several groundnut fields using the Boyoucous hydrometer method indicated that the soils had over 80% sand. While these types of soils are particularly suitable for groundnut because of easy peg penetration and pod formation, they could be prone to frequent drought due to the low water retention capacity.

1.1 _Selection of Farmer and agronomic survey_ - Twenty-six (26) groundnut farmers were selected for this study with the help of extension workers. The farmers were clustered within six villages namely: Xavi (5 farms), Agornu (6 farms) and Ahwlavikope (8 farms) Liveh (3 farms), Akpokope (2 farms) and Bedzokope (2 farms). The number of farms surveyed in each village approximately reflects the intensity of groundnut farming during the 2006 season. The common groundnut variety grown was *Kpedevi* which was early maturing. About 90 % of the surveyed farms were owned by women and groundnut-farm sizes ranged from 0.10 to 0.80 ha with a most common size of 0.20 ha. On these farms, about 50 % of the farmers mixed groundnut with other crops while the rest were sole groundnut farms. Farmers reported that typically they sell about 85% of the production for cash at the harvest with domestic consumption less than 15 %. The farms were visited at the time of harvest (July/August 2006). Each farmer was interviewed in the local language on aspects such as gender, total farm size, proportion of land allocated to groundnut in the season (March to July 2006), proportion of groundnut sold, their general perceptions on climate variability, access to forecast climate information and their coping strategies. After the interview, three 1.0 m^2 areas were harvested from each farm and the pod **yields (70% threshing %) were determined at 14% moisture content** after oven drying at 65 ^{o}C for 48 hours.

1.2 Farmers Responses to 2006 Rainfall Pattern

1.2.1 _Expectations of 2006 seasonal Rainfall_ - One-thirds of the 26 interviewed farmers in Akatsi, who had no access to rainfall forecast, had predicted a "good" 2006-rainy season with normal to above-normal rainfall during March-July major season. According to the October-Dec (OND) ENSO phase, 2006 March-July rainy season at Akatsi was forecasted to be a La Nina by IRI with potentially above normal (Base period 1971-2000) rainfall. Thus for some farmers, their forecast was the same as the IRI forecast. Normal to above normal major season rainfall at Akatsi signifies arrival of early rains. Generally with similar production practices, farmers believe that when groundnuts are planted early, thy yield higher than those plated later. In spite of this, only 2/3rds of the one-third farmers that believed that 2006 would be a "good" season were able to respond by planting groundnut early before 7th April. The majority of farmers were able to plant groundnuts between April 8th and-May 15th 2006.

1.2.2 *Planting Dates* - Farmers were not able to recall their exact date of planting groundnut, but were able to identify approximate week of planting. Planting dates ranged from mid-March to early May. For analysis purpose, the planting dates were classified into 3 groups: (i) early planting (mid- March- to first week of April), normal planting (second week of April to the end of April planting) and late planting in May. There were 6 (23%), 12 (43%) and 8 (31%) farmers who had sown their groundnuts during the three planting windows. Of the farmers interviewed, 70 % were unable to forecast the seasonal rainfall and the bulk of them planted normally. Some farmers (~30%) who "predicted" a good seasonal rainfall, about 60% of them planted early. On the contrary, most of the farmers in Xavi (60%) expressed no foreknowledge of the season's outcome and also planted late. At Ahwlavikope, about 63 % planted normally and 25 % planted late. Generally, those farmers who could or did not think of seasonal rainfall quality, planted at normal time. Farmers were unable to advance any specific reason, associated with expected seasonal rainfall, being the reason behind their choice of planting date. Most of these farmers were well aware of the increased climate variability but most of them are felt they could not do anything about it.

1.2.3 *Groundnut Pod Yield* – Every farmer who participated in this survey sold groundnuts as green pods immediately around the harvest time. From the 26- farmers yields, the median yield was 1251 kg/ha with a lower (Q1) and upper quartile (Q3) of 1059 and 1534 kg/ha. If we classify yields above Q3 as "above normal", between Q1-Q3 as "normal" and below Q3 as "below normal", majority of the farmers who planted late in May, harvested below-normal yields. Early planting (6 farms) gave higher median yield of 1288 kg/ha with a low inter quartile range (Q3-Q1) or IQR of 273 kg/ha. Normal planting resulted in a median yield of 1293 kg/ha but a higher variability (IQR = 432 kg/ha). Late planting resulted in the lowest median yield of 1000 kg/ha and a large variability (IQR = 712 kg/ha). In effect, normal time and late plantings were more risky in 2006. Farmers with bigger farm size harvested 550 kg/ha more as well as those who's major activity was groundnut farming (using land devoted to groundnut as its proxy) also harvested more groundnuts.

1.2.4 *Sale of Groundnut* - About 75% (range 80-100%) of the groundnut production was sold at harvest. Farmers indicated that they have special interest in groundnut because as an early crop, it can be harvested and fresh green pods can be sold easily in the market. The proceeds from this sale are used to defray costs incurred in financing their farming activities in the minor season (land preparation, fertilizer, labor etc) and social costs (clothing, school fees, health-care etc).

1.2.5 *Land allocated to groundnut* **–** There appears to be a pattern between percentage of farm size allocated to groundnut and planting date among the 26-surveyed farmers. Farmers, about 25%, who sown groundnuts during the early planting window devoted about 64% of their land holding to groundnut compared to 83% of land by farmers who waited and planted during the normal planting window. Farmers who waited to plant in May also cultivated about 70% of their land into groundnut.

2.0 *Survey of Groundnut Production Practices in Wa, Upper West Region of North Ghana* **–**
A sample of 21 willing farmers in two villages of Pissi and Nakor, near Wa were selected in early March 2006 and were monitored throughout the 2006 season to document their peanut production strategies. Farmers were not given the 2006 forecast and they were free to follow their own preferred production

practices. We monitored for each farmer, planting dates, plant density at the harvest, management practices such as weeding, fertilizer application and pest and disease control. At harvest time, plants from a 1-m^2 area were harvested and the pods and haulm yields were determined at 14% moisture content. Soils samples were collected from the 0-30-cm soil depth in each farmer's field and texture determined by the hydrometer method. Soils in the surveyed villages were loamy sand (58%) and sandy loam (32%).

Researchers also planted peanut fields on the research station in 2006. Researcher's field had sandy loam (79% sand, 11% clay) soils, pH of 6.2, bulk density of 1.45, medium to high in N and K, but low in available P. The field was split into 2- one half was sprayed with *Folicur* fungicide beginning about 28 days after planting to control early leaf spot disease, while other was not sprayed. Spraying has been proved to work in research studies but is not practiced by farmers, mostly due to lack of availability of chemicals. Each of the fields was further divided into 4- sub fields, one for each of the 4 sowing dates. These fields were sown on 17 June, 24 June, 1 July, and 8 July. Groundnuts were planted on flat seedbed at a density of 20 plants per m2. Weeds were controlled manually using hoes when necessary.

2.1 Planting date - Farmers' planted peanuts between 16 April to 30 June. Ten out of 21 farmers (47%) planted in April, 8 or 38% planted in May and 3 or 14 % planted in June; no farmer planted in July. Three farmers, who planted in June, planted on June 4, 19 and 30th. Farmers planting calendar matched daily rainfall recorded at Wa station about 10 Km, except the first planting on April 16 (Figure. 1). We believe that this farmer would not have planted without rain, although no rain was recorded at the station. In this tropical environment, it is not uncommon to rain in the area but not where the rain-gauge is located at. Fields on the research stations were sown on 17 June, 24 June, 1 July, and 8 July.

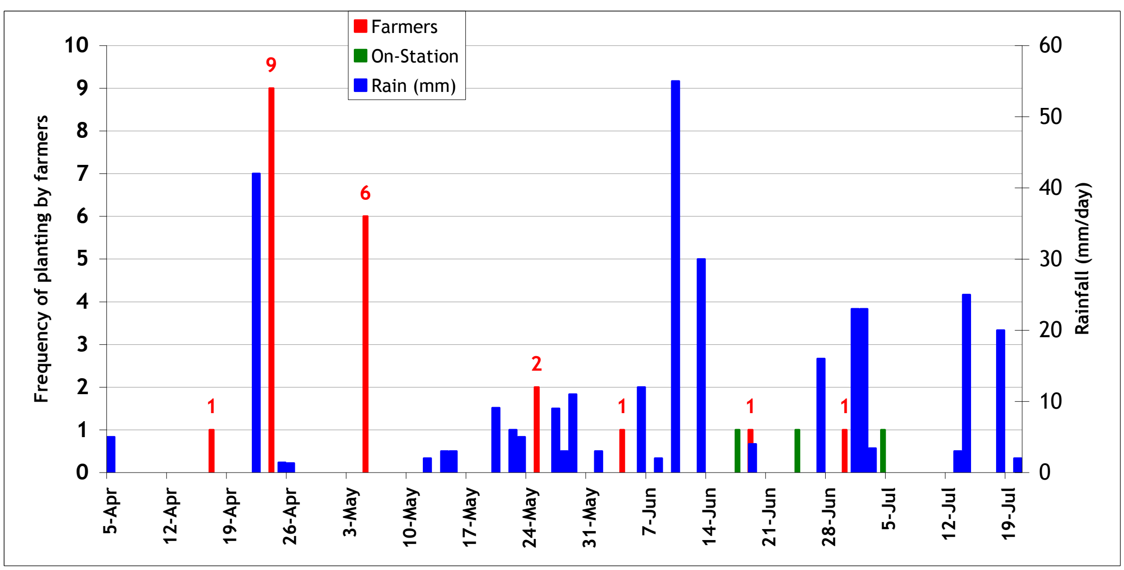


Figure 1. April 5-July 20 daily rainfall at Wa in 2006 (blue bars) and number of farmers (red bars) and researchers (green bars) planting groundnuts.

2.2 Sowing Density - For groundnuts, researchers recommend 20 pl/m^2 in the fields at harvest, this usually means that planting population density needs to be higher than 20 pl/m^2. Since groundnut seeds are expensive, farmers field densities are usually less than 20 pl/m^2 as this survey showed. Plant populations at harvest varied among the 21-farmers, ranging from 6 to 13 plants per m^2 with the most common density of 9 pl/m^2. On small plots on the research station, the planting density was maintained at 20 pl/m^2.

2.3 Choice of Variety – There was a clear difference in what farmers preferred and researchers chose to plant in 2006. Farmers chose among two improved varieties of groundnut in 2006. These were cv. Chinese, a 90 days cultivar and cv. Manipinter, a 120 days cultivar. No local cultivar was encountered among the 21-farmers monitored. Among the varieties being cultivated, one third (32.3%) farmers cultivated the 90-day improved Chinese variety and two thirds (67.7%) cultivated 120-day Manipinter. Researchers preferred cv. Chinese over Manipinter.

2.4 Pod Yields - As shown in Fig. 2, late May, early June harvested more groundnuts than any other planting date.

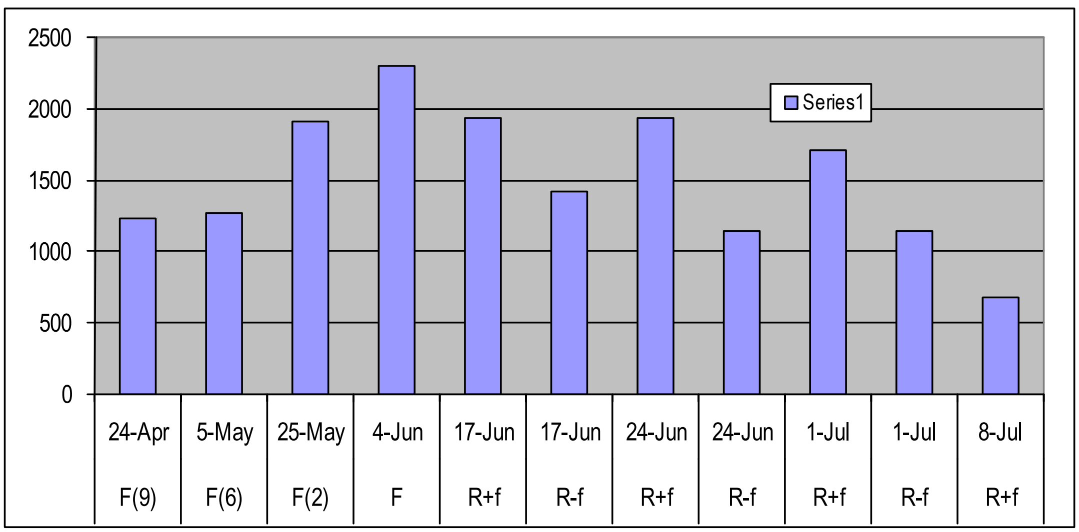


Figure 2. Variations in pod yield (kg/ha, 14% moisture) with sowing dates. R+f refers to researchers trials with fungicide and R-f refers to researchers trials without fungicide.

3.0 Survey of historical production and Impacts of ENSO - The Upper West Region falls within the savannah ecosystem. It is, therefore, a high agricultural 'risk zone' or otherwise called 'severe agricultural climate', where scarcity of precipitation and rainfall variability are not ideal for agriculture without irrigation. It lies close to the desert serving as an entry point of the advancing desert. Any human activity that damages the ecology has effects on agricultural productivity and can exacerbate famine. Cropping is the main agricultural activity in the area. Fields are generally small (<2ha) with no traces of large scale commercial cropping or cash cropping. Anyone who wish to visit this area, takes 15 hours to cover eight hundred kilometres. For the UWR this means it would be too expensive to transport crops to the south. Moreover, the region does not have much to offer in terms of crops. The farmers already have difficulty producing enough food for their own consumption, not to mention producing surplus for export. The third reason why there is no cash cropping, is that the soils are not fertile enough to produce large quantities of

crops and the environment is only suitable to a small variety of crops, which are not very popular for export. So the most common agricultural practice is subsistence farming.
During recent years (1986-2000) Wa received on average 16% less rainfall in an El Ninõ year than a average year. While it received 15% more rains during a La Ninã year. During the same period, agricultural productivity of major food crops was strongly influenced by ENSO phenomenon. Using mean over many years as a basis for comparison, yields during 1986-2000 were 6 to 37% higher in a La Ninã year, and 11 to 18% lower in an El Ninõ year. ENSO effects explain, and by extrapolation, predict large impacts on the economy of the region. For example with average 2003 market prices, and estimated production in 2006, which is a La Ninã year, the 13% increase in regional yields following La Ninã events would worth 52 Billion CDs in 2006. The 10% yield reduction following El Ninõ event of 2007 is estimated to cost the region 48 Billion CDs.

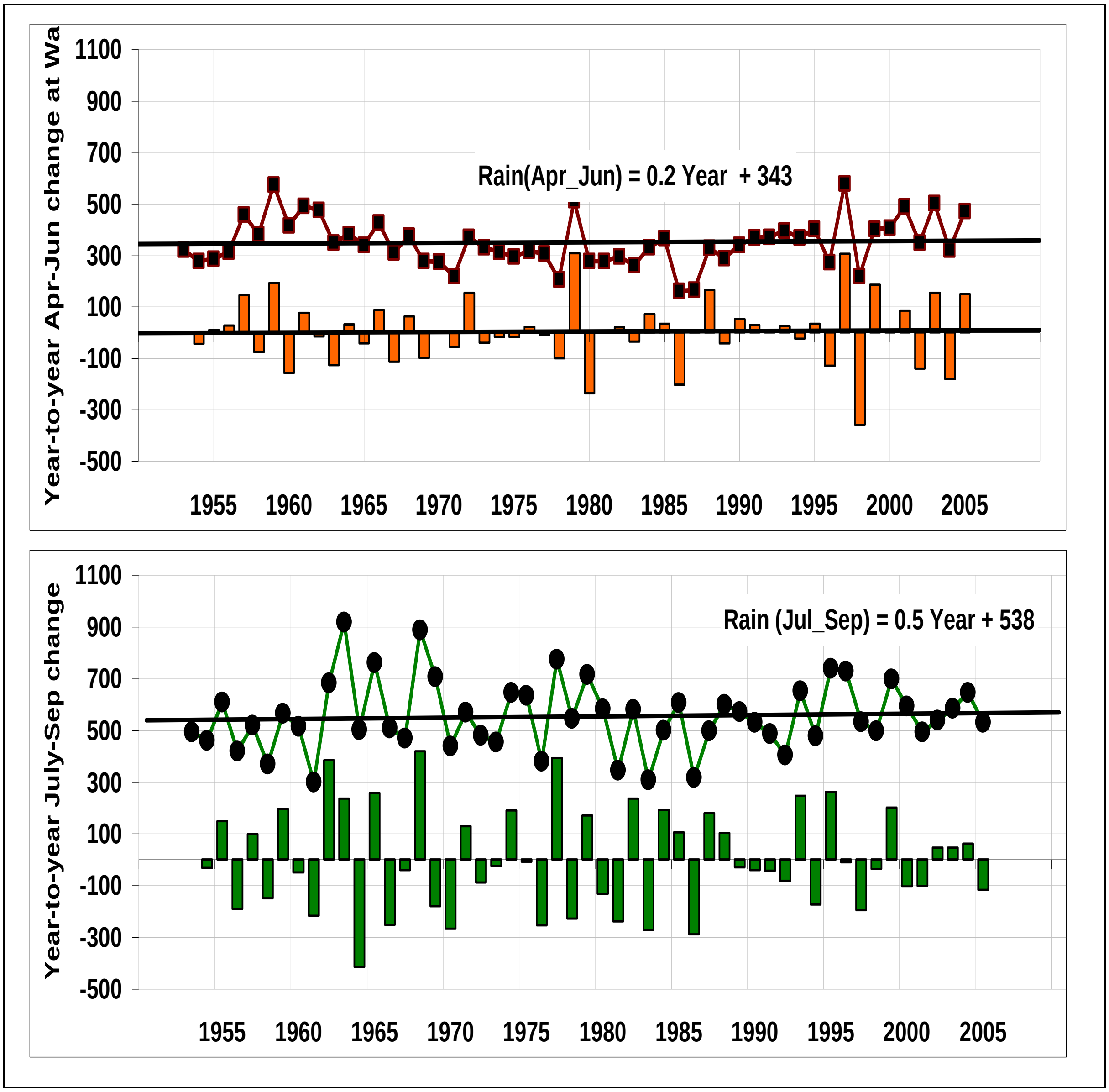
4. *Weather data analysis* - Given that the most variable climate factor in this region is rainfall, this project focused mainly on seasonal rainfall variability. Monthly rainfall records from 1953 to present were obtained from the Ghana Meteorological Agency, Accra. Time series plots were used to assess trends in the data. The seasonal rainfall for each year was determined and ranked from lowest to highest, for the determination of the cumulative probability distribution. The quartiles of the distribution were determined and interpreted as follows: (i) Q1 = below normal or poor season, Q2 = normal season and (iii) Q3 = above normal season. The onset and end dates for each year were determined following the method of the Meteorological Agency. Furthermore, the current daily rainfall data were extracted from GTS reports at ftp://ftp.cpc.ncep.noaa.gov/fews/gts/ to monitor evolving situation in the region.

Combining daily rainfall with soil properties, probability of crop failures were calculated. Results show higher frequency of crop failures in an El Nino year. Rainfall appears to be influenced by global circulation phenomenon such the ENSO. El Niño conditions leads to late onset and below normal rainfall while La Nina conditions lead to early onset and above normal rainfall. These observations suggest that the ENSO could become an operational tool in agricultural planning in the region.

Analyses of year-to-year changes in rainfall for Wa in Northen Ghana and Akatsi in Southern Ghana indicates that rainfall at the beginning of the rainy season has become more erratic since 1995 than over the previous 40-year period. On the other hand, rainfall has become more stable towards the end of the rainy period over the same period. The April-June period approximately coincide with active planting season for major crops, while July-September is the active growing and grain formation period.

5. **Decision Support System for Agricultural Applications of Climate Forecast in West Africa**

Climate variability, particularly rainfall plays an important role in the production risks faced by farmers in Ghana. A Decision Support System for Agricultural Applications of Climate Forecast (DSSAC) has been designed to assist in managing risks by showing potential adaptive response and their benefits. DSSAC is a proactive tool for use by extension agents, agricultural researchers, NGO's, policy makers and farmers who may use it to aid in decision making concerning management adjustments in light of climate forecasts.



B. Research findings

Surveys in Northern and Southern Ghana showed that groundnut was a cash crop for these farmers, who devote a large portion of their land for its production and sold 75% of their production immediately at the harvest in 2006. Farmers prefers to plant as soon as rains arrive, and those who planted early usually produced higher yields than 70% farmers who planted later. Most farmers late did not take into consideration rainfall variability; they were thinking of markets and being able to get enough cash returns to finance other farm activities and social obligations. All farmers reported that they had no access to climate information. Regional historical evidence presented above is compellingly clear that there is an opportunity to manage crop production, once ENSO phase is known. The region creates surplus production in a La Ninã year while deficit is likely in an El Ninõ year.

C. Papers.

Adiku, SGK, E, Atika, S. S. Jagtap, A. Nkansah, L. Atidoh, J.W, Jones, S. Duadze, and J.B. Naab, 2006. Climate variability and farmers' response in the goundnut producing areas of the Akatsi District of Ghana, African Soil Science Journal (Submitted)

D. 2007 Work-Plan

1. Distribute 2007 forecast to extension services and encourage them to work with farmers to implement it in their decision making process
2. Conduct field days to evaluate benefits of climate forecast to communities
3. Conduct training on Decision Support System
4. Make necessary corrections
5. Publish findings
6. Final report